Using CFD for Gasifier Components design

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Agenda

- Introduction: GE Energy & GE's Gasification
- Examples on how GE is using CFD for designing gasifier components with multiphase flow science and Challenges we are facing
- Conclusion

A typical GE quench gasifier

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GE Energy

Power & Water

- Thermal
- Renewables
- Nuclear
- Water treatment
- Process chemicals

Energy Services

- Contractual agreements
- Smart Grid
- Field services
- Parts and repairs
- Optimization technologies
- Plant management

Oil & Gas

- Drilling/production for … land, offshore, subsea
- LNG and pipelines
- Refining/petrochemical
- Industrial power gen
- Complete lifecycle services

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GE Power & Water… power generation platforms

Thermal

- **Gas turbines**
  - Heavy duty (40–500MW)
  - Aeroderivatives (18-100MW)
  - Combined cycle systems
- **Steam turbines**
- **Gasification**
  - IGCC
  - Gasification Licensing

Renewables

- Wind
  - Land based
  - Offshore
- Solar
  - Grid connected
  - Stand alone
- Jenbacher
  - Gas engines 0.3-3MW
  - Fueled with waste gas

Nuclear

- ABWR & ESBWR
- Adv nuclear fuel
- CANDU fuel & services
- Reactor & field services
- Performance services
- Nuclear isotopes

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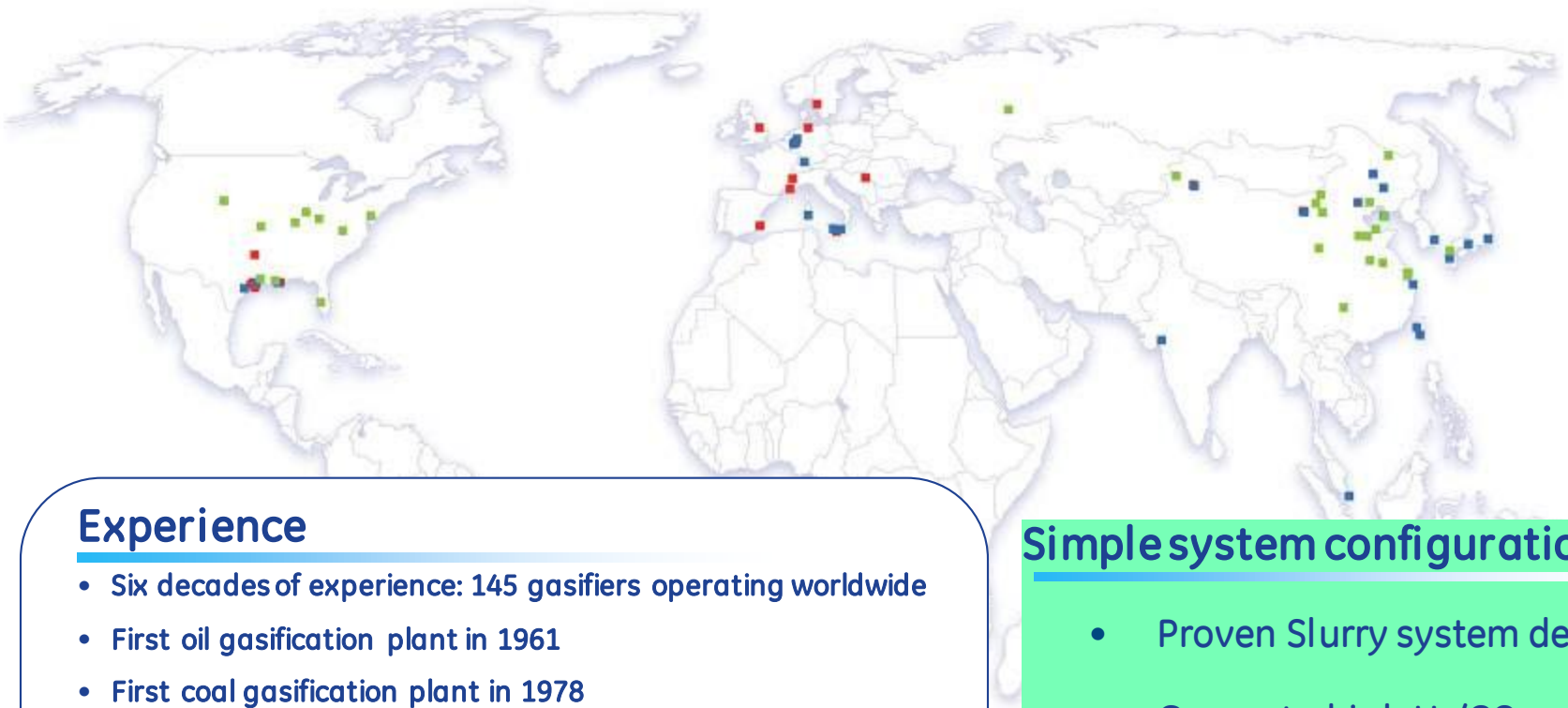
GE Gasification & IGCC Technology



Experience

- Six decades of experience: 145 gasifiers operating worldwide
- First oil gasification plant in 1961
- First coal gasification plant in 1978
- First pet coke gasification plant in 1984
- 30 gas turbines operating on syngas … > 1 million operating hours
- IGCC leader… >3 GW with GE Energy technologies
- 40 projects globally that separate CO_2

Simple system configuration

- Proven Slurry system design
- Generate high H_2/CO ratio
- Provides a size advantage for downstream systems

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Gasifier Modeling (Design Methods)

Objective

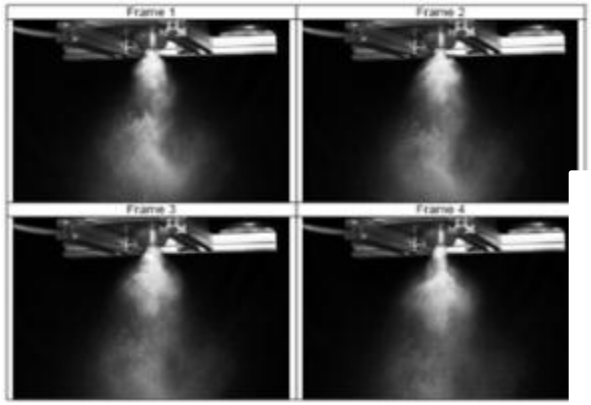
- Development & validation of robust, accurate & practical gasifier design method (DM)
- Quantify model predictive capability.

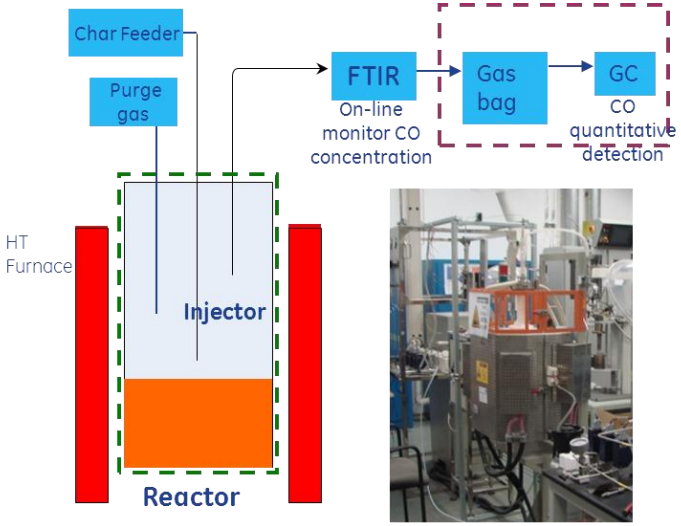
Business Impact

- Enable design comparisons of new gasifier concepts .
- Meet future customer needs.

Model development approach

- Sub-model searching, evaluation, and development
- Sub-model verification/validation
- Lab test/Data collection to provide data for sub-model inputs or validation





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Gasifier Modeling Overall Approach

Task	Focal	Schematic
Sub-model Integration into overall model		Spray model; Kinetics model; Flow-thermal model; FLUENT Solver; Inputs, Thermo-physical properties; Char-slag flow; Geometry/Mesh
Sub-model and overall gasifier model Verification & Validation		Lab - Plant scale; Verification & Validation; Bench scale; Sensitivity studies (Cells: 23 k, Cells: 94 k, Cells: 370 k); Pilot scale

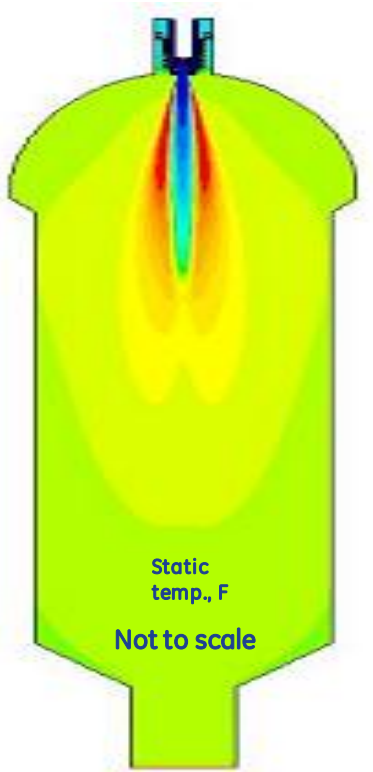
Accomplishments

Accomplishments

- ✓ Developed a series of gasifier model versions corresponding to new features or lesson learned
- ✓ Established & documented the best practices for model setup, execution & convergence criterions
- ✓ Quantification of grid error
- ✓ Quantification of plant BC sensitivity
- ✓ Validation spanning bench scale to plant scale

Example #1: Validation with a commercial plant:

Gasifier performance CTQ's	Relative Error (Model / Plant-data)	Uncertainty of Plant Data
Carbon conversion at exit	1%	± 2.25%
Syngas temperature at thermocouple	<1 %	± 90 F
% Carbon in "total slag"* at gasifier exit (dry basis)	10%	Plant data available after lock-hopper
Syngas composition at scrubber overhead, dry basis	MOLE CO2 5% CO 5% H2 5%	Plant data accuracy ± 1%



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Gasifier Modeling Challenges

Model

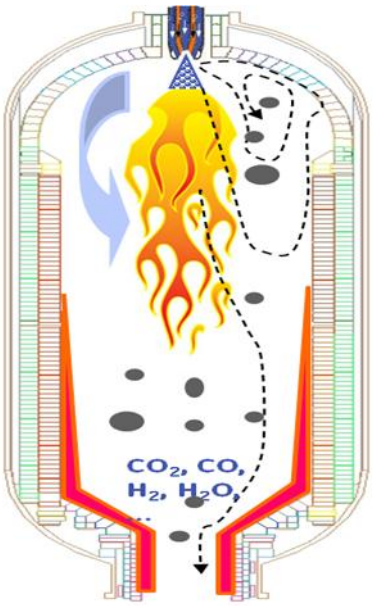
- Char particle reaction kinetics need to cover wider feed stock
- Particle radiation model
- Radiation, turbulence, reaction interaction
- High pressure atomization

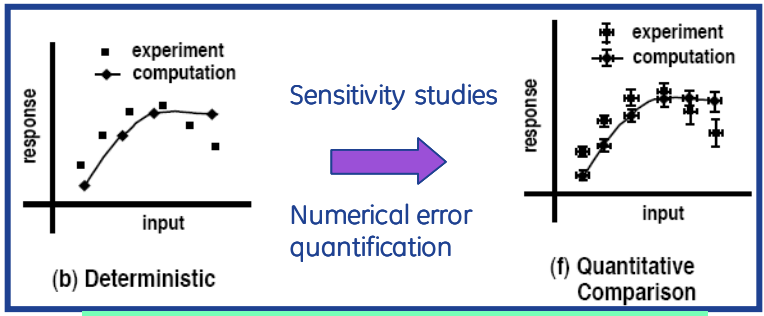
Data for validation

- ✓ High temperature measurement inside gasifier
- ✓ Flame detecting
- ✓ In-situ syngas composition measurement
- ✓ Uncertainty of measurement

Public opinion

- Difficult acceptance of CFD based analysis because the lack of fully understanding of all the physics.
- Negative effect of some careless CFD work.





Engineering design requires quantitative information

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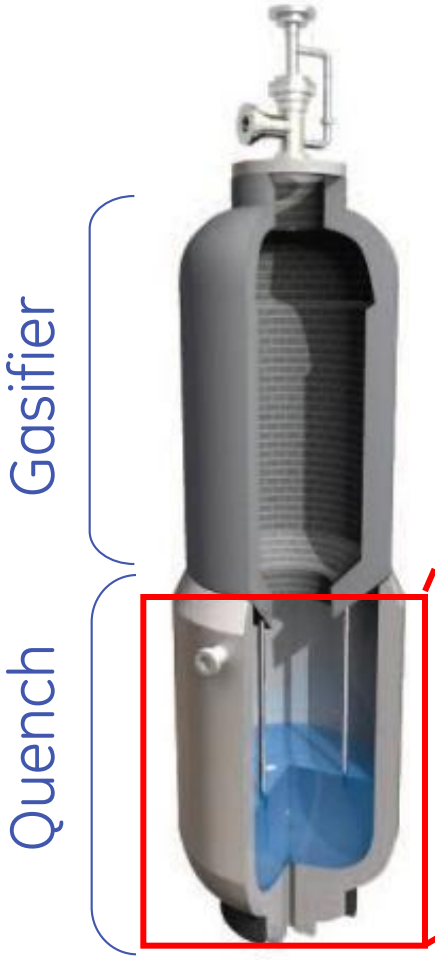
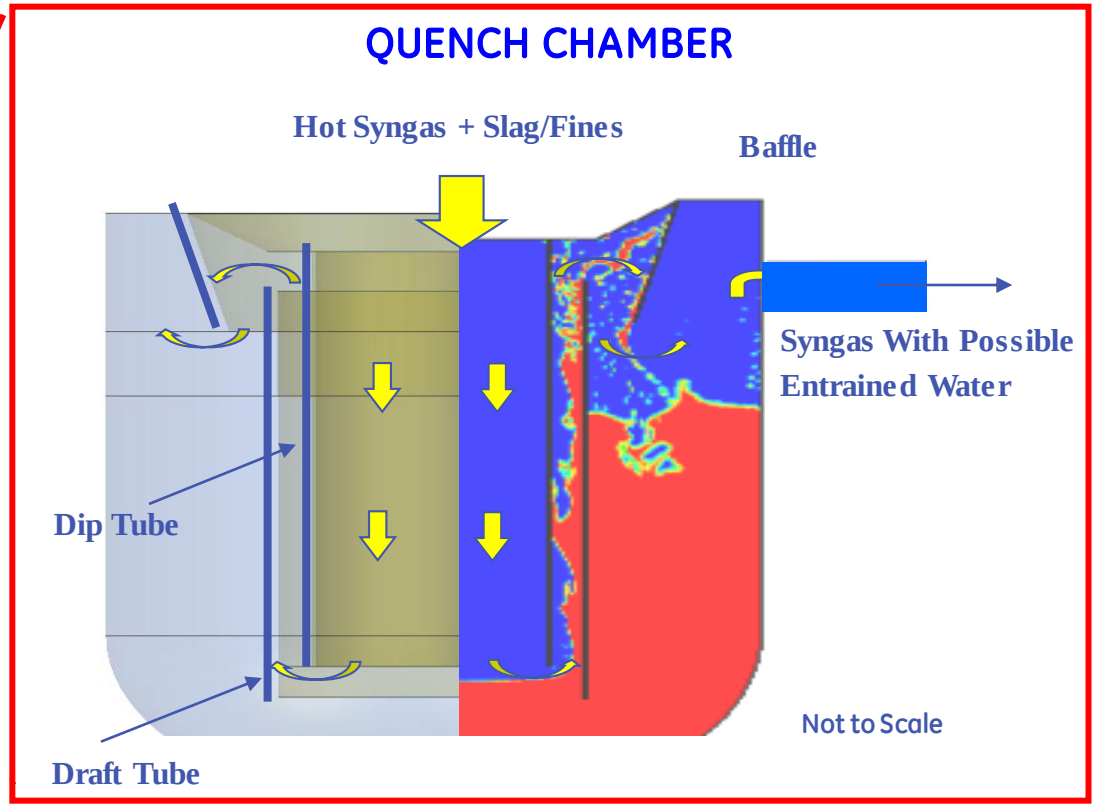
Quench Design Method Development

Objective: Develop validated design methods to predict Quench/Scrubber performance and optimize design and control

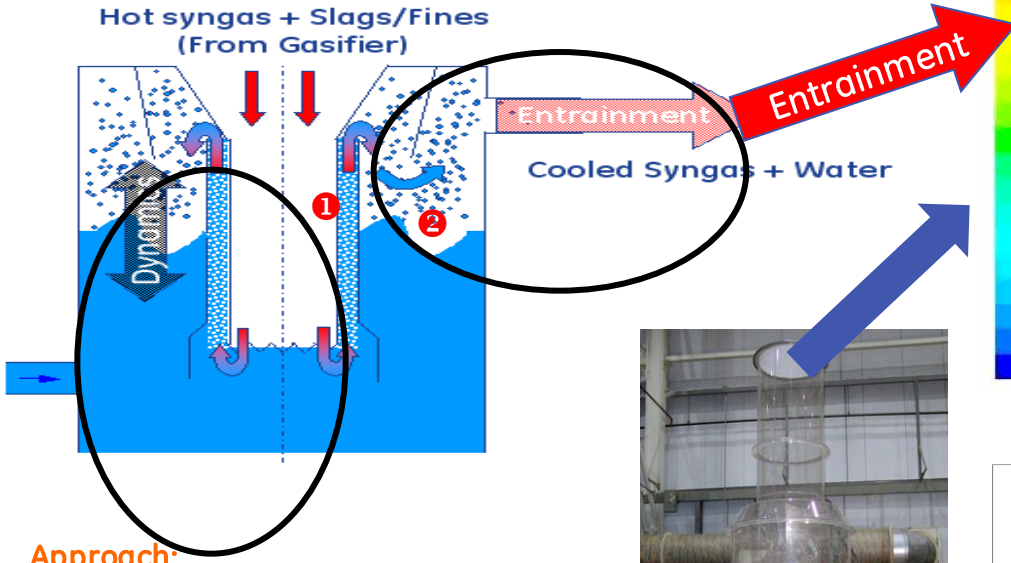




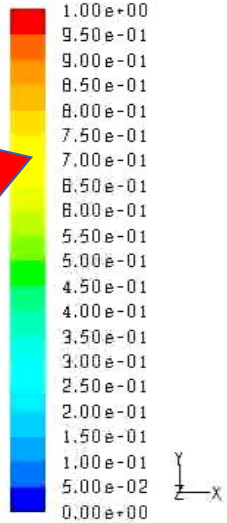
Using validated QG design methods to meet customer's requests		
• High throughput	• Low cost	• Stable operation
• Feasible to build	• Satisfied transportation limit	

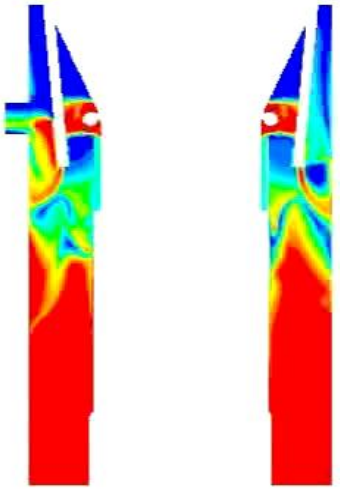
Approach and Challenges

❶ Primary entrainment
❷ Secondary entrainment



Entrainment



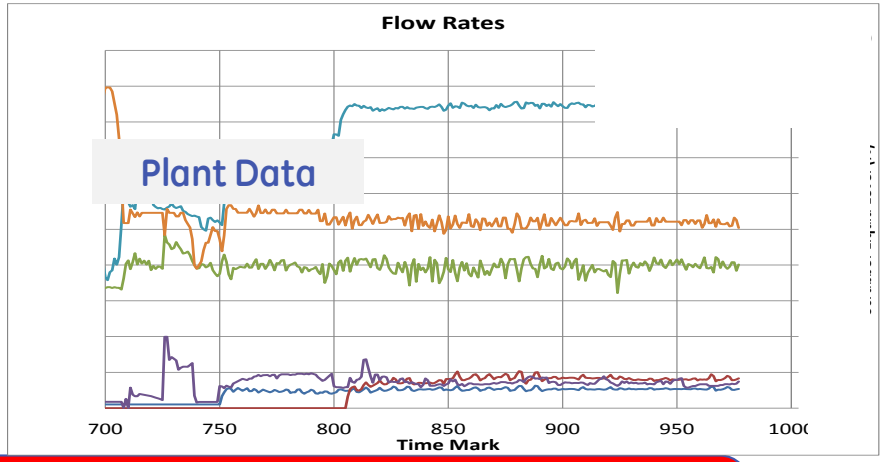


Not to Scale

Approach:

- Optimize design of quench internals.
- Test with lab scale rig
- Model developed based on physics
- Model validated on test rig and commercial plant.

Bench-scale Flow Testing



Needs: at high pressure and high temperature

- Droplet generation model; Liquid vaporization model
- Droplet-solid particle interaction and droplet-droplet interaction model

Conclusions

- Per advanced physics models combining with CFD, detailed insights can be discovered
- Validation and uncertainty quantification are critical
- Provide new tools for developing new technologies to meet customer's needs.

- Yet, there are gaps:
  - ✓ Physics models
  - ✓ Measurement/Data collection

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